CLAIMS

The claimed invention is:

1. A four-wheel-independent-steering-vehicle steering control method characterized in that; in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, one of the variables of the steering constraint condition equation is used as a steering command value S, in a process for changing the steering command value S from a value S_1 to a value S_2 for transitioning the wheel steering angles α_1, α_2, α_3, α_4 from the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1}$, which correspond to the command value S_1, to the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S2}$, which correspond to the command value S_2,

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+\Delta S}$ corresponding to the steering command value $(S_1 + \Delta S)$, which is the steering command value S_1 to which an incremental steering command value ΔS has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+\Delta S}$;

after the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+\Delta S}$, and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+2\Delta S}$ corresponding to the steering command value $(S_1 + 2\Delta S)$, which is the steering command value $(S_1 + \Delta S)$ to which an additional incremental steering command value ΔS has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+2\Delta S}$;

from this point on, after steering angle conformance of the wheel steering angles α_1, α_2, α_3, α_4 has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1 + n\Delta S}$ corresponding to the steering command value $(S_1 + n\Delta S)$, which is the steering command value S_1 to which the incremental steering command value ΔS has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1 + n\Delta S}$; arrival of the steering angles α_1, α_2, α_3, α_4 at the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1 + n\Delta S}$ in steering angle conformance is detected; and the process is repeated until the steering angles α_1, α_2, α_3, α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S2}$.

2. A four-wheel-independent-steering-vehicle steering control method characterized in that, in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, one of the variables of the steering constraint condition equation is used as a steering command value S, in a process for changing the steering command value S from a value S_1 to a value S_2 for transitioning the steering angles α_1, α_2, α_3, α_4 from the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1}$, which correspond to the command value S_1, to the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S2}$, which correspond to the command value S_2,

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1 + \Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1 + \Delta S}$ corresponding to the steering command value $(S_1 + \Delta S)$, which is the steering command value S_1 to which an incremental steering command value ΔS has been added, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+\Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1+\Delta S}$;

after the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+\Delta S}$, and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+2\Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1+2\Delta S}$ corresponding to the steering command value $(S_1 + 2\Delta S)$, which is the steering command value $(S_1 + \Delta S)$ to which an additional incremental steering command value ΔS has been added, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+2\Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1+2\Delta S}$;

from this point on, after steering angle conformance of the wheel steering angles α_1, α_2, α_3, α_4 is detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+n\Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1+n\Delta S}$ corresponding to the steering command value $(S_1 + n\Delta S)$, which is the steering command value S_1 to which the incremental steering command value ΔS has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+n\Delta S}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{S1+n\Delta S}$; arrival of the steering angles α_1, α_2, α_3, α_4 at the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1+n\Delta S}$ in steering angle conformance is detected; and the process is repeated until the steering angles α_1, α_2, α_3, α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{S2}$.

3. A four-wheel-independent-steering-vehicle steering control method characterized in that, in steering control wherein, by changing how a steering

command value is taken the direction of travel of a vehicle is changed by separately controlling the steering angles α_1, α_2, α_3, α_4 of the four wheels of the vehicle in accordance with steering constraint condition equations for forming a prescribed steering mode, wherein for the case wherein the turning-vehicle-travel-paths of the wheels form concentric arcs, a command value is defined as a distance R, which is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs, in a process for changing the steering command value R from a value R_1 to a value R_2, for transitioning the steering angles α_1, α_2, α_3, α_4 from the steering angle values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1}$, which correspond to the command value R_1, to the steering angle values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R2}$, which correspond to the steering command value R_2;

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$ corresponding to the steering command value ($R_1 + \Delta R$), which is the steering command value R_1 to which an incremental steering command value ΔR has been added, are computed as values that will satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$;

when the steering angles α_1; α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$ and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+2\Delta R}$ corresponding to the steering command value ($R_1 + 2\Delta R$), which is the steering command value ($R_1 + \Delta R$) to which an additional incremental steering command value ΔR has been added, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+2\Delta R}$, and

from this point on, proceeding in the same manner as above, when steering angle conformance of the steering angles α_1, α_2, α_3, and α_4 has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$ corresponding to the steering command value ($R_1 + n\Delta R$), which is the steering command value

R_1 to which the incremental steering command value ΔR has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$; and

when the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$ and steering angle conformance has been detected, the above process is repeated, continuing until steering angles, α_1, α_2, α_3, and α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R2}$.

4. A four-wheel-independent-steering-vehicle steering control method as recited in claim 3, characterized in that, for the case wherein the turning-vehicle-travel-paths of the wheels are concentric arcs, the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{L}{R-W}\right)$$

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{L}{R+W}\right)$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

R, which is used as the steering command value, is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs.

5. A four-wheel-independent-steering-vehicle steering control method as recited in claim 3 characterized in that, for the case wherein the turning-vehicle-travel-paths of the wheels are concentric arcs, the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{2L}{R-W}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{2L}{R+W}\right)$$

$$\alpha_3 = \alpha_4 = 0$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

R, which is used as the steering command value, is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs.

6. A four-wheel-independent-steering-vehicle steering control method characterized in that, in steering control wherein, by changing how a steering command value is taken the direction of travel of a vehicle is changed by separately controlling the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 of the four wheels of the vehicle in accordance with steering constraint condition equations for forming a prescribed steering mode, wherein for case wherein the turning-vehicle-travel-paths of the wheels are concentric arcs, a command value is defined as a distance R, which is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs,

in a process for changing the steering command value R from a value R_1 to a value R_2, for transitioning the steering angles α_1, α_2, α_3, α_4 from the steering angle values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1}$, which correspond to the steering command value R_1, to the steering angle values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R2}$, which correspond to the steering command value R_2;

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+\Delta R}$ corresponding to the steering command value $(R_1 + \Delta R)$, which is the steering command value R_1 to which an incremental steering command value ΔR has been added, are computed as values that will satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+\Delta R}$, respectively;

when the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+\Delta R}$ and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+2\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+2\Delta R}$ corresponding to the steering command value $(R_1 + 2\Delta R)$, which is the steering command value $(R_1 + \Delta R)$ to which an additional incremental steering command value ΔR has been added, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+2\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+2\Delta R}$, and

from this point on, proceeding in the same manner as above, after steering angle conformance of the steering angles α_1, α_2, α_3, α_4 has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+n\Delta R}$ corresponding to the steering command value $(R_1 + n\Delta R)$, which is the steering command value R_1 to which the incremental steering command value ΔR has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{R1+n\Delta R}$; and

when the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1+n\Delta R}$ and steering angle conformance has been detected, the above process is repeated, continuing until the steering angles α_1, α_2, α_3, and α_4, respectively, have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{R2}$.

7. A four-wheel-independent-steering-vehicle steering control method as recited in claim 6 characterized in that, for the case wherein the turning-vehicle-travel-paths of the wheels are concentric arcs, the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{L}{R-W}\right)$$

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{L}{R+W}\right)$$

$$n_1 : n_2 : n_3 : n_4 = \sqrt{(R-W)^2 + L^2} : \sqrt{(R+W)^2 + L^2} : \sqrt{(R-W)^2 + L^2} : \sqrt{(R+W)^2 + L^2}$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3, and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

R, which is used as the command value, is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs.

8. A four-wheel-independent-steering-vehicle steering control method as recited in claim 6 characterized in that, for the case wherein the turning-vehicle-travel-paths of the wheels are concentric arcs, the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{2L}{R-W}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{2L}{R+W}\right)$$

$$\alpha_3 = \alpha_4 = 0$$

$$n_1 : n_2 : n_3 : n_4 = \sqrt{(R-W)^2+(2L)^2} : \sqrt{(R+W)^2+(2L)^2} : |R-W| : |R+W|$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3, and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

R, which is used as the command value, is the distance between a point central to the positions of the four wheels and a center point of said concentric arcs.

9. A four-wheel-independent-steering-vehicle steering control method characterized in that; in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, an angle α_n, the angle formed between a center line Y between the left and right wheels of the vehicle and the direction of travel of an arbitrary point Pn on the vehicle, is used as a steering command value; in a process for changing the steering command value αn from a value α_{n1} to a value α_{n2} for transitioning the wheel steering angles α_1, α_2, α_3, α_4 from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1}$, which correspond to the steering command value α_{n1}, to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n2}$, which correspond to the steering command value α_{n2},

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$ corresponding to the steering command value $(\alpha_{n1} + \Delta\alpha_n)$, which is the steering command value α_{n1} to which an incremental steering command value $\Delta\alpha_n$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$;

after the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$ and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + 2\Delta\alpha n}$ corresponding to the steering command value $(\alpha_{n1} + 2\Delta\alpha_n)$, which is the steering command value $(\alpha_{n1} + \Delta\alpha_n)$ to which an additional incremental steering command value $\Delta\alpha_n$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + 2\Delta\alpha n}$;

from this point on, after steering angle conformance of steering angles α_1, α_2, α_3, α_4 has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha 1 + n\Delta\alpha n}$ corresponding to the steering command value $(\alpha n_1 + n\Delta\alpha n)$, which is

the steering command value αn_1 to which the incremental steering command value $\Delta\alpha n$ has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + n\Delta\alpha n}$; arrival of the steering angles α_1, α_2, α_3, α_4 at the transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + n\Delta\alpha n}$ in steering angle conformance is detected; and the process is repeated until the steering angles α_1, α_2, α_3, α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n2}$.

10. A four-wheel-independent-steering-vehicle steering control method as recited in claim 9 characterized in that the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{L}{x_n + \frac{y_n}{\tan\alpha_n} - W}\right)$$

and

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{L}{x_n + \frac{y_n}{\tan\alpha_n} + W}\right)$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels;

x_n and y_n are the x and y coordinates of an arbitrary point on the vehicle, Pn; and

α_n, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Pn.

11. A four-wheel-independent-steering-vehicle steering control method as recited in claim 9 characterized in that the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{2L}{x_n + \frac{y_n}{\tan\alpha_n} - W}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{2L}{x_n + \frac{y_n}{\tan\alpha_n} + W}\right)$$

and

$$\alpha_3 = \alpha_4 = 0$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels;

x_n and y_n are the x and y coordinates of an arbitrary point on the vehicle, Pn; and

α_n, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Pn.

12. A four-wheel-independent-steering-vehicle steering control method characterized in that; in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, an angle α_n, the angle formed between a center line Y between the left and right wheels of the vehicle, and the direction of travel of an arbitrary point Pn on the vehicle is used as a steering command value; in a process for changing the steering command value α_n from a value α_{n1} to a value α_{n2} for transitioning the steering angles α_1, α_2, α_3, α_4 from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1}$, which correspond to the steering command value α_{n1}, to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n2}$, which correspond to the steering command value α_{n2},

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + \Delta\alpha n}$ corresponding to the steering command value $(\alpha_{n1} + \Delta\alpha_n)$, which is the steering command value α_{n1} to which an incremental steering command value $\Delta\alpha_n$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + \Delta\alpha n}$, after the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + \Delta\alpha n}$, and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + 2\Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + 2\Delta\alpha n}$ corresponding to the steering command value $(\alpha_{n1} + 2\Delta\alpha_n)$, which is the steering command value $(\alpha_{n1} + \Delta\alpha_n)$ to which an additional incremental steering command value $\Delta\alpha_n$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + 2\Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + 2\Delta\alpha n}$;

from this point on, after steering angle conformance of steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + n\Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + n\Delta\alpha n}$, corresponding to the steering command value $(\alpha n_1 + n\Delta\alpha n)$, which is the steering command value αn_1 to which the incremental steering command value $\Delta\alpha n$ has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ and speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + n\Delta\alpha n}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha n1 + n\Delta\alpha n}$, arrival of the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ at the transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1 + n\Delta\alpha n}$ in steering angle conformance is detected; and the process is repeated until the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha n2}$.

13. A four-wheel-independent-steering-vehicle steering control method as recited in claim 12 characterized in that the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{L}{x_n + \dfrac{y_n}{\tan\alpha_n} - W}\right)$$

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{L}{x_n + \dfrac{y_n}{\tan\alpha_n} + W}\right)$$

and

$$n_1 : n_2 : n_3 : n_4 = \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} - W\right)^2 + L^2} : \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} + W\right)^2 + L^2}$$
$$: \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} - W\right)^2 + L^2} : \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} + W\right) + L^2}$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3 and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels;

x_n and y_n are the x and y coordinates of an arbitrary point on the vehicle, Pn; and

α_n, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle and the direction of travel of the point Pn.

14. A four-wheel-independent-steering-vehicle steering control method as recited in claim 12 characterized in that the steering constraint condition equations for forming a prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{2L}{x_n + \frac{y_n}{\tan\alpha_n} - W}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{2L}{x_n + \frac{y_n}{\tan\alpha_n} + W}\right)$$

$\alpha_3 = \alpha_4 = 0$

and

$$n_1 : n_2 : n_3 : n_4 = \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} - W\right)^2 + (2L)^2} : \sqrt{\left(x_n + \frac{y_n}{\tan\alpha_n} + W\right)^2 + (2L)^2} : \left|x_n + \frac{y_n}{\tan\alpha_n} - W\right| : \left|x_n + \frac{y_n}{\tan\alpha_n} + W\right|$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3 and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels;

x_n and y_n are the x and y coordinates of an arbitrary point on the vehicle, Pn; and

α_n, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle and the direction of travel of the point Pn.

15. A four-wheel-independent-steering-vehicle steering control method characterized in that, in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, an angle α_o, the angle formed between a center line Y between the left and right wheels of the vehicle and the direction of travel of a point Po, the center point on a line connecting the left and right front wheels, is used as a

steering command value; in a process for changing the steering command value α_o from a value α_{o1} to a value α_{o2} for transitioning the steering angles α_1, α_2, α_3, α_4 from the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1}$, which correspond to the steering command value α_{o1}, to the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o2}$, which correspond to the steering command value α_{o2},

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$ corresponding to the steering command value $(\alpha_{o1} + \Delta\alpha_o)$, which is the steering command value α_{o1} to which an incremental steering command value $\Delta\alpha_o$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$;

after the steering angles α_1, α_2, α_3, α_4 have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$, and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + 2\Delta\alpha o}$ corresponding to the steering command value $(\alpha_{o1} + 2\Delta\alpha_o)$, which is the steering command value $(\alpha_{o1} + \Delta\alpha_o)$ to which an additional incremental steering command value $\Delta\alpha_o$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + 2\Delta\alpha o}$;

from this point on, after steering angle conformance of steering angles α_1, α_2, α_3, α_4 has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o + n\Delta\alpha o}$ corresponding to the steering command value $(\alpha o_1 + n\Delta\alpha o)$, which is the steering command value αo_1 to which the incremental steering command value $\Delta\alpha o$ has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles α_1, α_2, α_3, α_4 are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + n\Delta\alpha o}$; arrival of the steering angles α_1, α_2, α_3, α_4 at the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + n\Delta\alpha o}$ in steering angle conformance is detected; and the

process is repeated until the steering angles α_1, α_2, α_3, α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o2}$.

16. A four-wheel-independent-steering-vehicle steering control method as recited in claim 15 characterized in that the steering constraint condition equations for forming the prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{1}{\frac{l}{\tan\alpha_0} - \frac{W}{L}}\right)$$

and

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{1}{\frac{l}{\tan\alpha_0} + \frac{W}{L}}\right)$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

α_o, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Po, which is the center point on a line connecting the left and right front wheels.

17. A four-wheel-independent-steering-vehicle steering control method as recited in claim 15 characterized in that the steering constraint condition equations for forming the prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{1}{\frac{1}{\tan\alpha_0} - \frac{W}{2L}}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{1}{\frac{1}{\tan\alpha_0} + \frac{W}{2L}}\right)$$

and

$$\alpha_3 = \alpha_4 = 0$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

α_o, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Po, which is the center point on a line connecting the left and right front wheels.

18. A four-wheel-independent-steering-vehicle steering control method characterized in that in steering control wherein, by changing how a steering command value is taken for changing the direction of travel of a vehicle by separately controlling steering angles α_1, α_2, α_3, α_4 and speeds of rotation n1, n2, n3, n4 of the four wheels in accordance with steering constraint condition equations for forming a prescribed steering mode, an angle α_o, the angle formed between a center line Y between the left and right wheels of the vehicle, and the direction of travel of a point Po, the center point on a line connecting the left and

right front wheels, is used as a steering command value; in a process for changing the steering command value α_o from a value α_{o1} to a value α_{o2} for transitioning the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ from the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1}$, which correspond to the command value α_{o1}, to the values $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o2}$, which correspond to the command value α_{o2},

incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$ and incremental speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + \Delta\alpha o}$ corresponding to the steering command value $(\alpha_{o1} + \Delta\alpha_o)$, which is the steering command value α_{o1} to which an incremental steering command value $\Delta\alpha_o$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$ and the speeds of rotation n1, n2, n3, and n4 are changed toward the incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + \Delta\alpha o}$;

after the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ have reached the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + \Delta\alpha o}$, and steering angle conformance has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + 2\Delta\alpha o}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + 2\Delta\alpha o}$ corresponding to the steering command value $(\alpha_{o1} + 2\Delta\alpha_o)$, which is the steering command value $(\alpha_{o1} + \Delta\alpha_o)$ to which an additional incremental steering command value $\Delta\alpha o$ has been added, are computed as values that satisfy said steering constraint condition equation;

the steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + 2\Delta\alpha o}$ and the speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + 2\Delta\alpha o}$;

from this point on, after steering angle conformance of steering angles $\alpha_1, \alpha_2, \alpha_3, \alpha_4$ has been detected, incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + n\Delta\alpha o}$ and incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + n\Delta\alpha o}$ corresponding to the steering command value $(\alpha o_1 + n\Delta\alpha o)$, which is the steering command value αo_1 to which the incremental steering command value

$\Delta\alpha o$ has been added [n times] in succession, are computed as values that satisfy said steering constraint condition equations; the steering angles $\alpha 1$, $\alpha 2$, $\alpha 3$, $\alpha 4$ are changed toward the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + n\Delta\alpha o}$, the speeds of rotation n1, n2, n3, n4 are changed toward the incremental transition speeds of rotation $[n1, n2, n3, n4]_{\alpha o1 + n\Delta\alpha o}$; arrival of the steering angles α_1, α_2, α_3, α_4 at the incremental transition steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1 + n\Delta\alpha o}$ in steering angle conformance is detected; and the process is repeated until the steering angles α_1, α_2, α_3, α_4 have been changed from the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o1}$ to the steering angles $[\alpha_1, \alpha_2, \alpha_3, \alpha_4]_{\alpha o2}$.

19. A four-wheel-independent-steering-vehicle steering control method as recited in claim 18 characterized in that the steering constraint condition equations for forming the prescribed steering mode are

$$\alpha_1 = -\alpha_3 = \tan^{-1}\left(\frac{1}{\dfrac{l}{\tan\alpha_0} - \dfrac{W}{L}}\right)$$

$$\alpha_2 = -\alpha_4 = \tan^{-1}\left(\frac{1}{\dfrac{l}{\tan\alpha_0} + \dfrac{W}{L}}\right)$$

and

$$n_1 : n_2 : n_3 : n_4 = \sqrt{\left(\frac{L}{\tan\alpha_0} - W\right)^2 + L^2} : \sqrt{\left(\frac{L}{\tan\alpha_0} + W\right)^2 + L^2}$$
$$: \sqrt{\left(\frac{L}{\tan\alpha_0} - W\right)^2 + L^2} : \sqrt{\left(\frac{L}{\tan\alpha_0} + W\right)^2 + L^2}$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3, and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

α_o, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Po, which is the center point on a line connecting the left and right front wheels.

20. A four-wheel-independent-steering-vehicle steering control method as recited in claim 18 characterized in that the steering constraint condition equations for forming the prescribed steering mode are

$$\alpha_1 = \tan^{-1}\left(\frac{1}{\frac{1}{\tan\alpha_0} - \frac{W}{2L}}\right)$$

$$\alpha_2 = \tan^{-1}\left(\frac{1}{\frac{l}{\tan\alpha_0} + \frac{W}{2L}}\right)$$

$$\alpha_3 = \alpha_4 = 0$$

and

$$n_1 : n_2 : n_3 : n_4 = \sqrt{\left(\frac{2L}{\tan\alpha_0} - W\right)^2 + (2L)^2} : \sqrt{\left(\frac{2L}{\tan\alpha_0} + W\right)^2 + (2L)^2} : \left|\frac{2L}{\tan\alpha_0} - W\right| : \left|\frac{2L}{\tan\alpha_0} + W\right|$$

where

α_1, α_2, α_3, and α_4 are the steering angles of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

n1, n2, n3, and n4 are the speeds of rotation of the right front wheel, left front wheel, right rear wheel, and left rear wheel, respectively;

L is the distance between each wheel and a center line X between the front wheels and rear wheels;

W is the distance between each wheel and a center line Y between the left wheels and right wheels; and

α_o, which is used as the steering command value, is the angle formed between the center line Y between the left and right wheels of the vehicle, and the direction of travel of the point Po, which is the center point on a line connecting the left and right front wheels.

21. A four-wheel-independent-steering-vehicle steering control method as recited in claim 1 characterized in that the addition of an incremental steering command value to the steering command value is performed no more than three times.

22. A four-wheel-independent-steering-vehicle steering control method as recited in claim 1 characterized in that the prescribed steering mode is arbitrarily selected from a plurality of modes comprising vehicle forward travel and reverse travel modes; and when the steering mode is changed, the individual wheel steering angles α_1, α_2, α_3, and α_4 are first reset to the straight ahead travel direction $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$; after which the wheel steering angles α_1, α_2, α_3, and α_4 are separately changed in accordance with the steering constraint condition equations for forming the prescribed steering mode.

23. A four-wheel-independent-steering-vehicle steering control method as recited in claim 1 characterized in that the prescribed steering mode is arbitrarily selected from a plurality of modes comprising vehicle forward travel and reverse travel modes; and when the steering mode is changed, drive for moving the vehicle is applied [only] after the individual wheel steering angles α_1,

α_2, α_3, and α_4 are such that they satisfy the steering constraint equations that will apply after the steering mode is changed.